

REMARKS

Claim 1 has been amended to clarify that the process of the invention is applicable to all of the 7 listed types of water. Support for the limitation that the calcium source is "a sole agent" can be found throughout Applicants' specification, in the numerous disclosed embodiments, all of which use "milk of hydrated lime" as the sole agent to precipitate a first product.

Minor other changes to the wording of the claim do not introduce new matter into the claim. Claim 2 has been amended to recite a salinity range of 1 to 60g/L. This is in conformity with Table 1 which recites this range for TDS of Type 1 water. At page 13, lines 23 and 25-26 of the originally filed PCT application, it is made clear that the TDS value relates to salinity. Claim 15 has been amended to clarify the nature of the "diverted water". As Type 1 water is used in the process of this claim, the Applicant submits that it is clear that the added water would also be Type 1 water, and therefore that this amendment does not add new matter to the claim. Claim 16 has been amended so as to combine the features of claim 16 and cancelled claim 17. No new matter has been added herewith.

Indefiniteness

Claims 1, 2, 5-19, 21, 22 and 24-26 were rejected under 35 U.S.C. § 112, second paragraph as being indefinite. In particular, "in the event" in Claim 1, "diverted water" in Claim 16, "light" in Claim 19, and "RO" in Claim 24 were found to be vague and indefinite and it was unclear how they further limited the claims.

Regarding the term "in the event", Claim 1 clearly lays out two possibilities for the first solid product. These depend on the nature of the water used in the process: Type 1 water produces PCC whereas Types 2 to 7 produce GMH. The term "in the event" used with each of these possibilities indicates this. Accordingly, the Applicants consider that the term was not indefinite. However, to simplify the claim and further clarify its intention, the referenced phrase has been replaced by "if."

Regarding the term "diverted water", Applicants assume the Examiner meant to refer to claim 15, not claim 16, since the latter claim does not include this phrase. Claim 15 is presently amended to specify addition of Type 1 water as the diverted water.

Regarding the term "light" in claim 19, the term "magnesium carbonate light" is well known in the art. The Specification as filed defines magnesium carbonate light (MCL) at page

24, lines 12-13 as $X.MgCO_3.Y.Mg(OH)_2.Z.H_2O$. One of ordinary skill in the art would understand that X, Y and Z denote integers. Thus, the skilled artisan would understand that the term includes the defined group of compounds.

The Examiner asserts that the term "RO" in claim 24 is indefinite. Claim 24 is amended to explicitly recite "reverse osmosis (RO)."

In view of the amendments to the claims and the preceding remarks, the Applicants respectfully request that the rejections under 35 U.S.C. § 112, second paragraph be withdrawn.

Obviousness

Weinberger et al.

Claims 1, 2, 5-7, 11, 12, 14-18 and 24-26 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Weinberger et al. (U.S. Patent No. 3,350,292). The Examiner considers the method of saline water by Weinberger *et al.* to be patentably indistinguishable from the treatment of water types 1-7 in the present application. However, without exception, all process routes disclosed by Weinberger et al. involve simultaneous dosing with Na_2CO_3 and one or more additional reagents selected from CaO, NaOH, and NaCl. However, in every example disclosed in Weinberger et al., Na_2CO_3 is a common component of the mixed reagents added to sea water to induce $CaCO_3$ precipitation as a sludge. In addition, CO_2 gas injection to aid or induce $CaCO_3$ precipitation is indicated in Figure 3. In contrast, the presently claimed process utilizes a calcium ion source as a sole agent in step (a) to cause at least some solids dissolved in the water to react with the first reagent and to form a first solid product and a partially processed water. Thus, the first reagent utilized in the presently claimed process does not include Na_2CO_3 , as clarified by the amendment to Claim 1.

In the process described by Weinberger et al., simultaneous addition of $Ca(OH)_2$ and Na_2CO_3 reagents has the significant disadvantage of causing these two reagents to react with each other to form an impure mixture of $CaCO_3$ and NaOH, which mixture will include $CaSO_4$ impurity, and thus be of no or limited use unless further treated. Also, because of a lower solubility of $CaCO_3$ compared with gypsum ($CaSO_4 \cdot 2H_2O$), substantial quantities of CaO and Na_2CO_3 reagents will be expended in the ion exchange step in order to reduce the sulfate content of the feed before the treated water can be subjected to physical conversion. By way of contrast, in the presently claimed process the lime reagent (i.e., calcium oxide, calcium hydroxide, or a combination thereof) is applied in a single step or in two separate steps in stoichiometric amounts

under controlled mixing condition, which enables efficient control of product quality and minimizes reagent waste. The presently claimed process results in the production of high quality, commercial-grade products. For example, a gypsum magnesium hydroxide (GMH) mixture is the first product stream from treatment of sea water type feed (claim 8). $Mg(OH)_2$ may be obtained from process water after the recovery of GMH using a second lime dosing step, as described in claim 10.

Moreover, as with all conventional treatment methods for softening the sea water before its beneficial use, the process routes employed by Weinberber et al. (Figures 1 to 3) involve the combined application of different types and mixtures of reagents aided by carbonation, ion exchange, acidification, and aeration (CO_2 release) steps. These are known to be necessary for softening sea water (with respect to calcium, magnesium and sulfate ions) before water recovery in thermal processes, or other beneficial uses including but not limited to electrolysis for Cl_2 and NaOH recovery. In contrast, the presently claimed process, whether applied to sea water or other water types specified in this application, neither uses mixed reagents nor applies any and all of the carbonation, ion exchange, acidification, aeration (CO_2 release) steps cited in Weinberger et al. As such, the presently claimed processes are conducive to zero liquid discharge (ZLD) outcomes.

It is common knowledge that the use of ion exchange at high pH, as described by Weinberger et al., is not sufficiently efficient for the removal of the bulk of sulphate ion and requires additional treatment steps and costs, including brine regeneration step and waste disposal. Thus, in addition to process complication and reduced recovery of NaCl product, such a process is known to add substantially to the treatment cost. However, in the presently claimed process, the removal of sulfate ion may be achieved by stoichiometric addition of hydrated lime slurry to sulphate-rich water to remove the bulk of sulfate ion and generate a spent water suitable for recovery of NaCl salt product, as described in claim 8. According to process in claim 10, a second lime dosing step may be used for the recovery of high grade $Mg(OH)_2$ from spent water of first-step lime dosing, before the use of spent water for NaCl salt production. This is an unexpected advantage that was not appreciate by the prior art.

Weinberger et al. has identified an acidification step as an essential step in the process for generating pure water in the physical conversion step. This acidification step releases CO_2 gas. In alternative process routes (Figs. 2 and 3) lime is replaced by Na_2CO_3 and/or CO_2 gas injection

to aid or induce CaCO_3 precipitation. In any event, all of the described process options are not generators of CO_2 gas. In contrast, neither an acidification step nor CO_2 gas addition steps are required in the present process for recovery of CaCO_3 and magnesium-based products from sea water type feed. In fact, the present process converts dissolved CO_2 gas in feed water to a valuable product, and therefore represents a CO_2 capture and recovery process. This is an additional unexpected advantage that was not appreciated by the prior art.

In all three process options disclosed by Weinberger et al., (Figs. 1 to 3) the spent water after $\text{Mg}(\text{OH})_2$ or ion exchange separation is rich in sulfate ion, potentially impacting the efficiency of a subsequent physical conversion step. All three process routes suffer from a gypsum scaling problem in the physical conversion step, as the processed water after $\text{Mg}(\text{OH})_2$ separation or ion exchange step will be still highly charged with respect to dissolved sulfate ion. This represents a major process deficiency. Further, the internal recycling of a NaOH stream from the electrolysis step for recovery of CaCO_3 (Figs 2 and 3) is a costly practice and provides problems for product quality control. In the present process, to produce a high grade $\text{Mg}(\text{OH})_2$ product, as shown in Figure 7, a simple two step process is applied to water types 2, 4, 5, 6, 7 wherein stoichiometric addition of calcium oxide, hydrated lime slurry or a combination thereof in the first step of the process is followed by a second lime reaction step. The product from step 1 is GMH and from step 2 is a high grade $\text{Mg}(\text{OH})_2$. This two-step process provides a simple product quality control measure yet enables the removal of the bulk of dissolved sulfate ion content of process water for further beneficial use of the spent water.

In the processes disclosed by Weinberger et al., calcium, magnesium and sulfate ion removal steps are essential in the described process for removing the hardness and minimizing, preventing or reducing scale formation in the evaporators. However, the solid products from these "softening" steps are known in the industry to be of mixed composition and therefore of limited value or commercial use unless further treated. On the other hand, sulphate and magnesium removal in the present process is achieved in four process steps, common to all water types, and result in commercial grade products. This unexpected advantage of the presently claimed process refutes the alleged *prima facie* obviousness.

In view of the amendments to the claims and the preceding remarks, the claims are in compliance with 35 U.S.C. § 103(a). Accordingly, the Applicants respectfully request that the rejection be withdrawn.

Weinberger et al. and Jongema

Claim 13 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Weinberger et al. (*supra*) in further view of Jongema (U.S. Patent No. 5,221,528). The Examiner stated that it would have been obvious to one skilled in the art to modify the process of Weinberger et al. by further concentrating the mother liquid in view of the teachings of Jongema, to aid in recovering sodium sulfate from the water. However, as discussed above, the presently claimed process is distinct from Weinberger et al., in that it utilizes a calcium ion source as a sole reagent in step (a). Both Weinberger et al. and Jongema disclose simultaneous dosing with two or more reagents, which include Na_2CO_3 . Jongema discloses at Column 1, lines 55-59 that, to remove calcium and magnesium ions from brine, both Na_2CO_3 and calcium hydroxide may be added to form calcium carbonate and magnesium hydroxide, respectively, which are subsequently removed. Thus, Jongema does not provide any additional information to the skilled artisan that would have led to the development of the presently claimed process, which, as discussed above has unexpected advantages over the prior art. Thus, the fact that Jongema recovers sodium sulfate from water is irrelevant.

Moreover, the object of Jongema is NaCl salt purification from a crude brine obtained from the dissolution of raw/crude salt in water. In contrast, Claim 13 seeks a two-fold objective: firstly to recover a useful sodium sulfate salt and secondly the reduction of pH of process water after CaCO_3 recovery from type 1 water (alkaline water) to between 8 and 9. Sulfuric acid is used to achieve this two-fold objective. The crude brine, as per the teachings of Jongema and according to chemical compositions given in two examples in the patent, has a TDS salinity substantially over 60 g/L, otherwise the process is not workable. Further, the only product from Jongema process is purified salt, and the impure Na_2SO_4 is recycled, rather than made available as a useful byproduct.

Jongema's brine purification in one or more vessels (vessels marked as "B" in Figure 1 and "E" in Figure 2) requires the addition of "various compounds" ("4" in Figure 1, "15" in Figure 2) to the vessels to induce precipitation of impurities ("5" in Figure 1 and "16" in Figure 2). According to the teachings of Jongema, these various compounds are added simultaneously to the vessels and may include Na_2CO_3 , $\text{Ca}(\text{OH})_2$ and CO_2 gas. The addition of these various compounds, as contemplated by Jongema, to a spent water after CaCO_3 separation, according to the teachings of Weinberger et al. (Figs. 1, 2 and 3) will result in a mixed salt of no beneficial

use, unless further treated at substantially added costs. In contrast, in present claim 13, the only reagents added to the alkaline feed (type 1 water) is a calcium ion source for the recovery of calcium carbonate in step 1. This is followed by addition of sulphuric acid for reduction of pH and recovery of Na_2SO_4 product. This stepwise addition of reagents is in direct contrast to the processes of *Weinberger et al.* and *Jongema*, both of which require the simultaneous addition of more than one reagent in mixed crystalline, slurry or solution form. Neither of the cited documents disclose a feature other than the simultaneous addition of two or more reagents to achieve their stated objectives.

Contrary to the Examiner's assertion, in *Jongema* process the addition "only" of $\text{Ca}(\text{OH})_2$ to a brine will not generate a CaCO_3 product and a purified brine, as the process requires the addition of one or more sources of carbonate ion (e.g. in the form of Na_2CO_3 and/or CO_2 gas) according to disclosures in *Jongema* (col. 4, line 8 and line 63). In present claim 13, the source of carbonate ion is the alkaline feed water (type 1 water) itself. Therefore, the present process for stepwise product recovery (wherein the first product after reaction with hydrated lime slurry is calcium carbonate and the second product after acidification is Na_2SO_4) is fundamentally different from the teachings of *Weinberger et al.* and *Jongema*.

Weinberger et al. and Heath et al.

Claims 21 and 22 were rejected under 35 U.S.C. § 103(a) as being unpatentable over *Weinberger et al.* (*supra*) in further view of *Heath et al.* (U.S. Patent No. 2,342,666). The Examiner concluded that these claims differ from *Weinberger et al.* by reciting that the partially processed water is further contacted with a solution of calcium chloride to convert carbonate ions to PCC and supplementary PCC respectively. The Examiner states that it would have been obvious to one skilled in the art to modify the process of *Weinberger et al.* by utilizing the recited calcium chloride solution in view of teachings of *Heath et al.* to aid in recovering PCC from the water.

However, as discussed above, the presently claimed process is distinct from *Weinberger et al.*, in that it utilizes a calcium ion source as a sole reagent in step (a). *Heath et al.* does not provide any additional information to the skilled artisan that would have led to the development of the presently claimed process, which as discussed above has unexpected advantages over the prior art.

Moreover, the processes in both Weinberger *et al.* and Heath *et al.* are related to the treatment of sea water for CaCO_3 production. As such, both require one or more external sources of carbonate (such as CO_2 gas and/or Na_2CO_3 reagent) in order to produce CaCO_3 from sea water feed. This fundamental requirement for an external source of carbonate ion, to make the patented processes in Weinberger *et al.* and Heath *et al.* work, is clearly indicated in these patents and associated process flow diagrams. On the other hand, Claims 21 and 22 of the present application are dependent claims of claim 6 and apply to alkaline water of type 1. As such the carbonate source for CaCO_3 production in the claimed two-step process, disclosed in claims 21 and 22, is the inherited bicarbonate ion of the feed water. This water type is fundamentally different from sea water. Consequently, the process steps identified in Weinberger *et al.* and Heath *et al.* are neither applicable nor relevant for the purpose of recovery of high grade precipitated CaCO_3 products as described in Examples 10 and 11.

The CaCO_3 recovery in the Weinberger *et al.* processes requires simultaneous reaction of two or more reagents with seawater. Although Heath *et al.* use lime slurry as the sole reagent for producing a mixture $\text{Mg}(\text{OH})_2$ and gypsum stream from seawater, their subsequent process steps for CaCO_3 recovery from the filtered slurry, using CaCl_2 brine, requires a carbonation step (CO_2 gas injection in this case) to induce CaCO_3 precipitation. If this step is omitted, the process would not work. Furthermore, the object of Heath *et al.* is to recover MgCl_2 solution or a partially hydrated MgCl_2 from sea water. Additionally, it would be obvious to one skilled in the art that sea water does not provide a suitable source of carbonate for the recovery of high grade precipitated calcium carbonate. In the present application, the sole reagent for primary CaCO_3 recovery from type 1 water is a source of calcium ion, such as calcium oxide, hydrated lime slurry or a combination thereof. As described in Examples 10 and 11, the process in claims 21 and 22, for the conversion of the bulk of dissolved bicarbonate in the alkaline feed to a calcium carbonate product by means of reacting the partially processed water and/or the solid phase with calcium chloride solution is fundamentally different in technical features from the patented process in Heath *et al.* The nature of type 1 water eliminates the need for the injection of CO_2 gas to induce the precipitation of CaCO_3 , as is the case with Heath *et al.*

In light of the amendments to the claims and preceding remarks, the claims are not obvious in view of the cited references. Accordingly, the Applicants respectfully request that the rejections under 35 U.S.C. § 103(a) be withdrawn.

New Claim 37

New claim 37 is directed to a process in which any of the recited types of water other than type 4 is treated. Type 4 water encompasses sea water, and is excluded from this new claim. As discussed above, Weinberger is limited to the treatment of sea water, and provides no suggestion that the process is applicable to water of Types 1-3 and 5-7.

No Disclaimers or Disavowals

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application. Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

CONCLUSION

In view of Applicants' amendments to the Claims and the foregoing Remarks, it is respectfully submitted that the present application is in condition for allowance. Should the Examiner have any remaining concerns which might prevent the prompt allowance of the application, the Examiner is respectfully invited to contact the undersigned at the telephone number appearing below.

A 2-month extension of time fee payment was previously paid on January 23, 2009.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

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